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Lonati et al.

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(54) **CIRCULAR KNITTING MACHINE WITH KNITTED ITEM REMOVAL/TRANSFERRING DEVICE**

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(52) **U.S. Cl.** ..... **66/149 S**; 66/148; 66/59
(58) **Field of Search** ..... 66/147, 148, 149 R, 66/150, 152, 153, 149 S, 13, 14, 17, 18, 58, 59, 8

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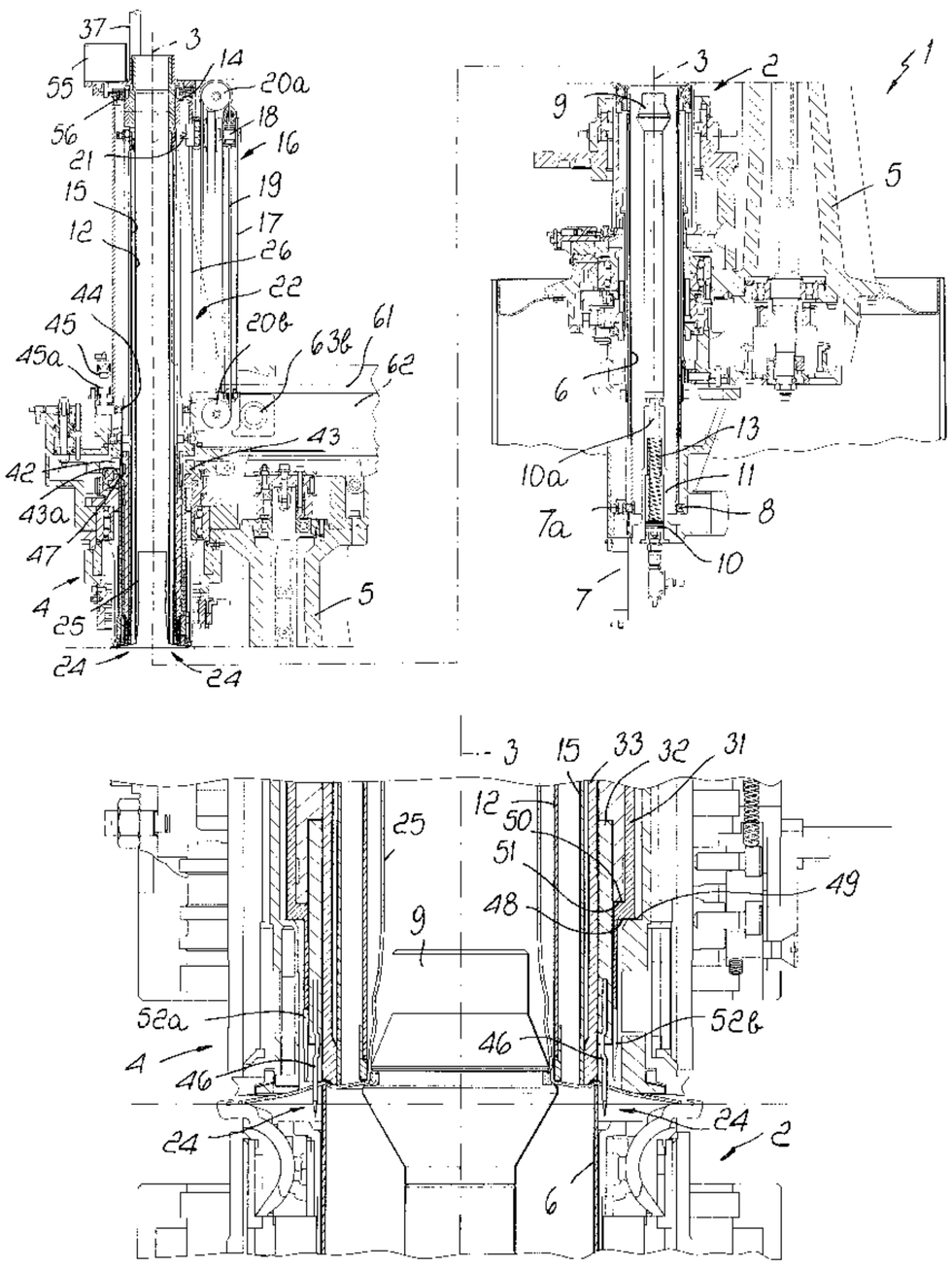
(57) **ABSTRACT**

A circular double-cylinder hosiery knitting machine with a device for removing and transferring the article at the end of the knitting process, comprising a lower and an upper needle cylinders with vertical axis, a device with a removal element insertable from above into the upper needle cylinder, provided with first grippers that engage the final end of the article and a transfer element, arranged above the upper needle cylinder to remove the article from the removal element and to feed it to a sewing machine.

29 Claims, 12 Drawing Sheets



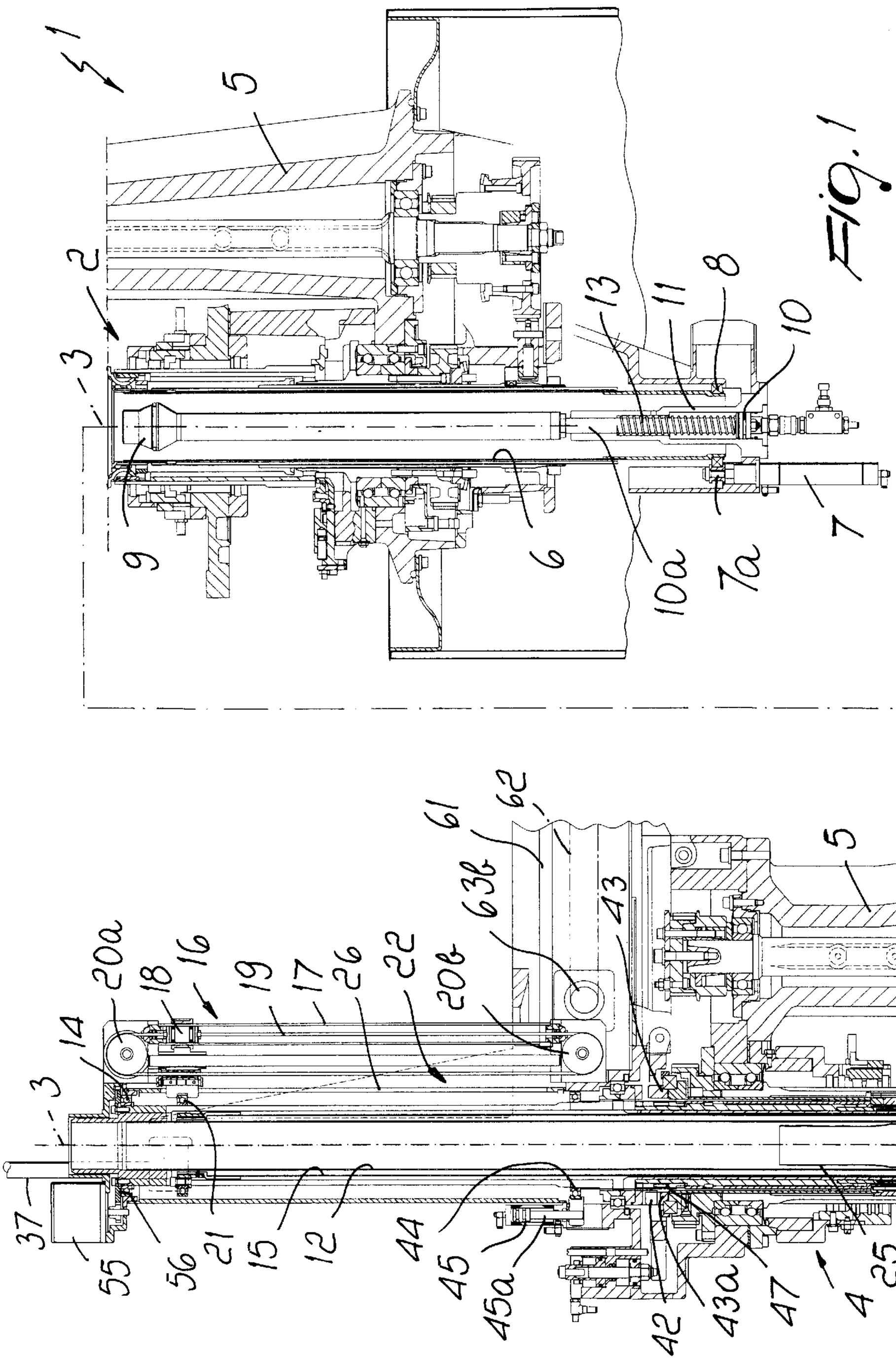

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Fig. 1
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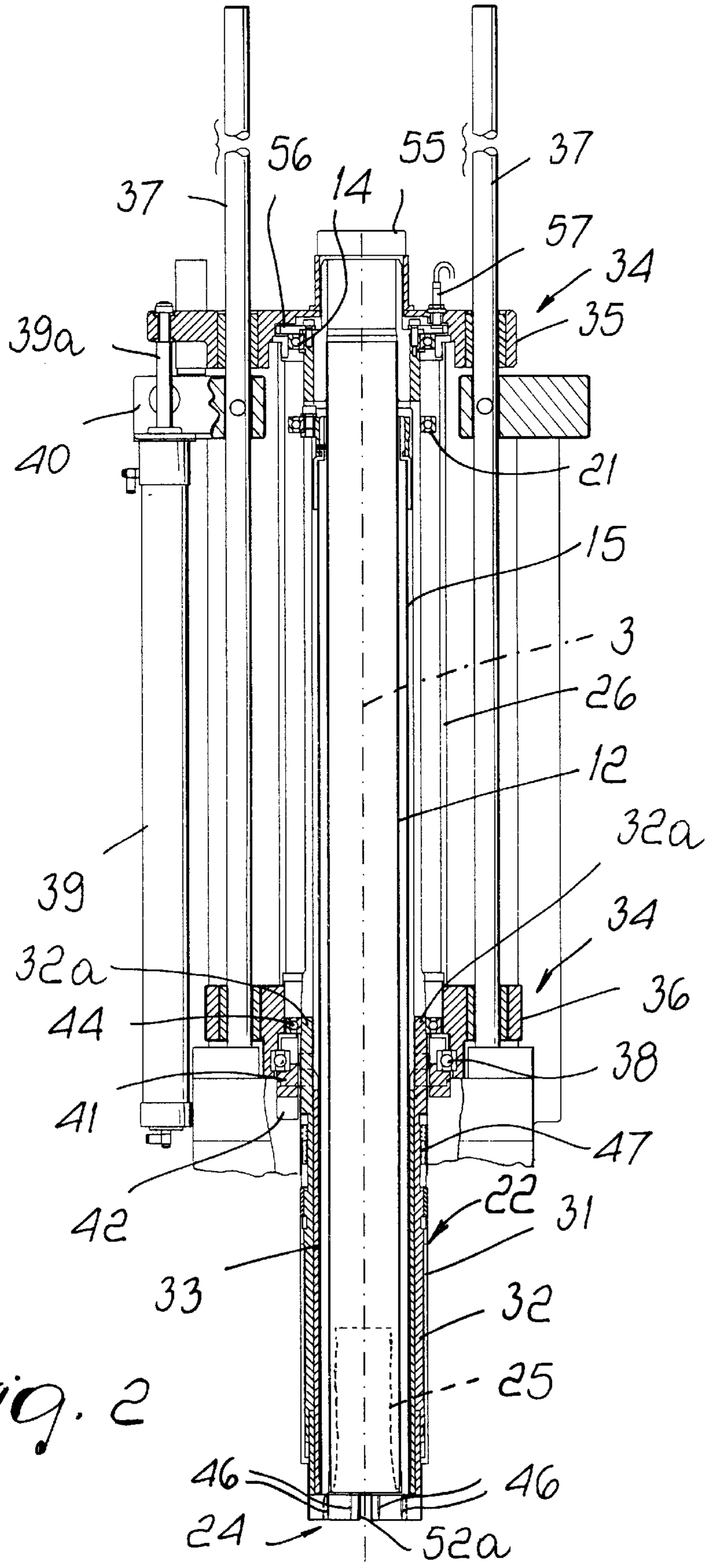
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Fig. 2

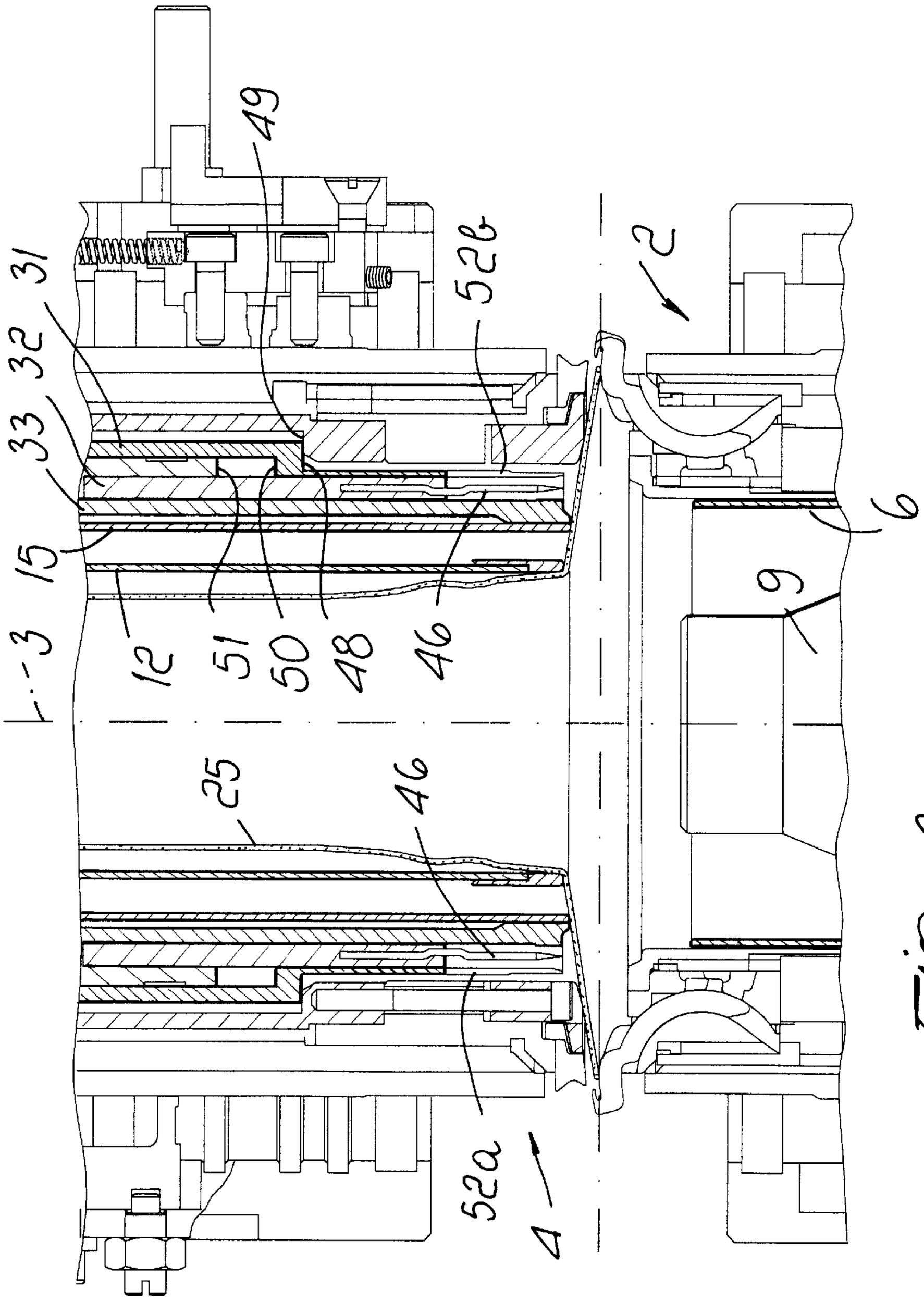


Fig. 3

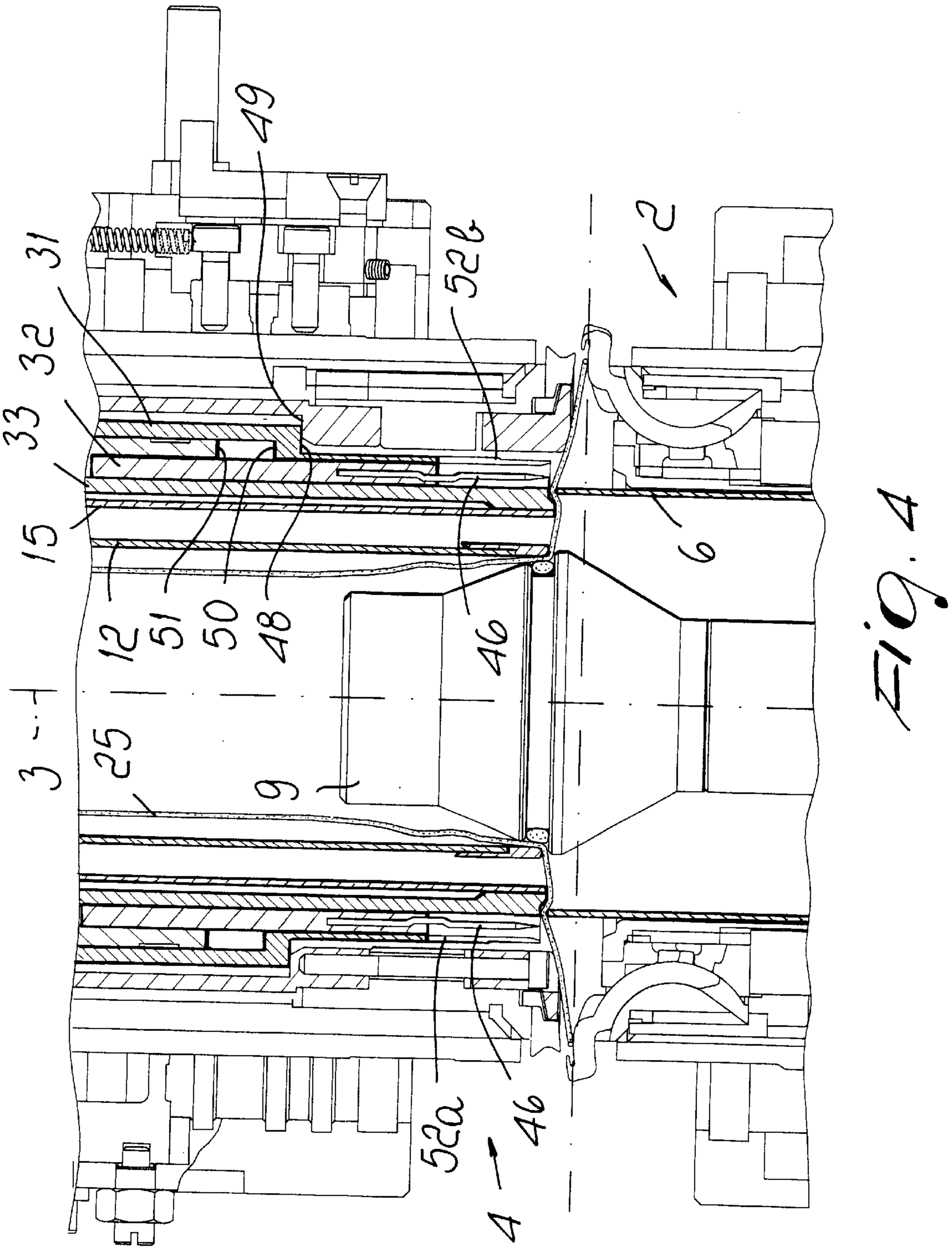


Fig. 4

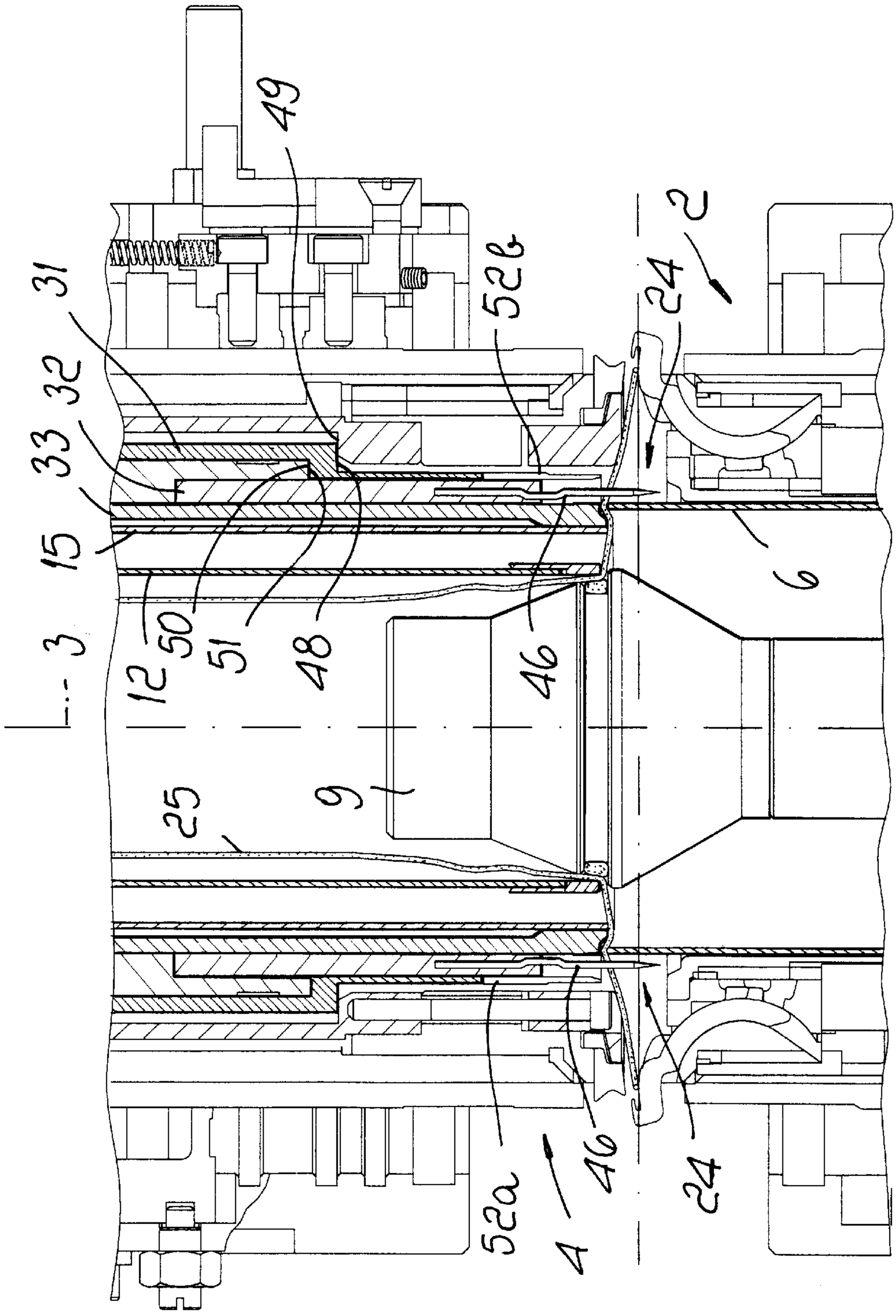


Fig. 5

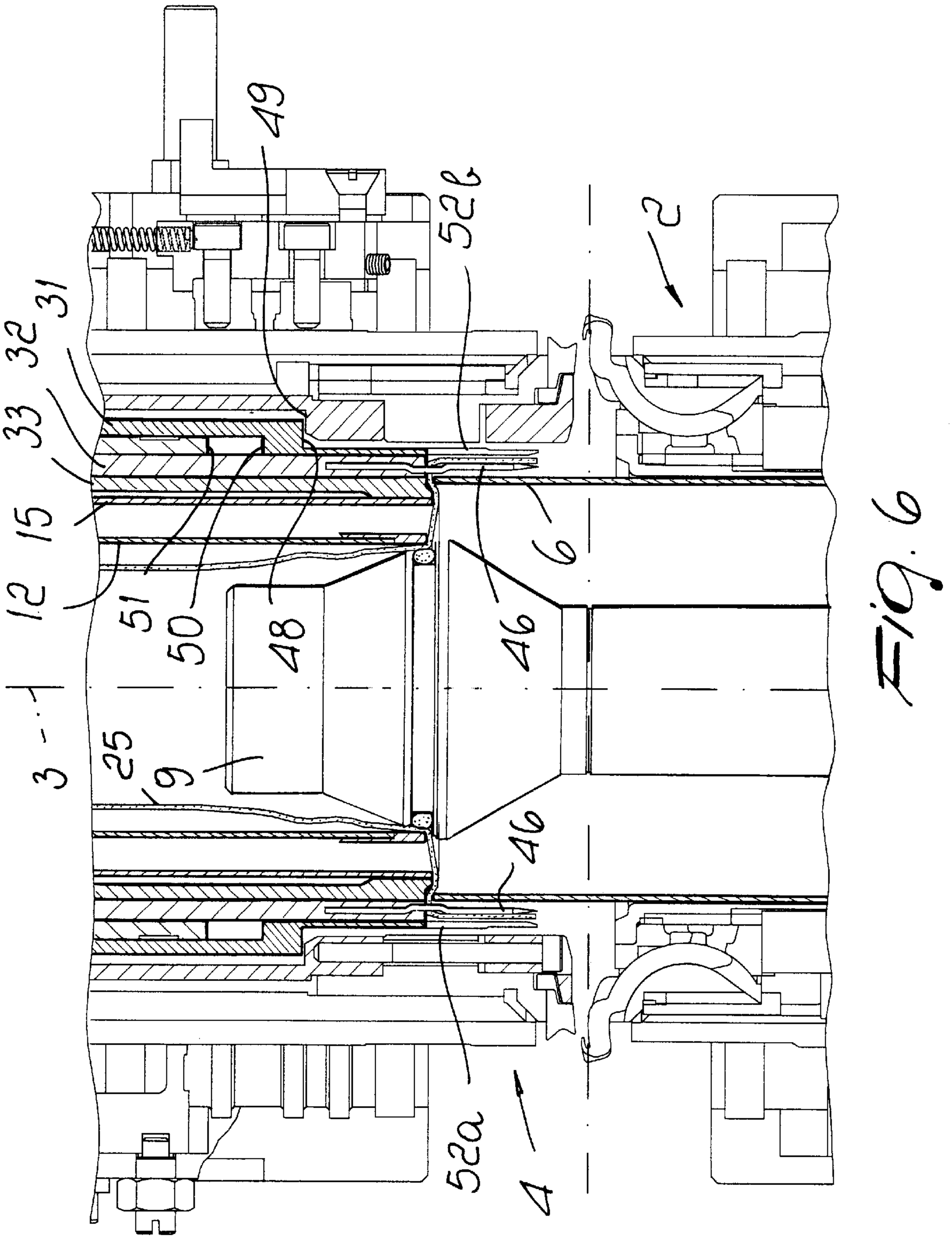


Fig. 6

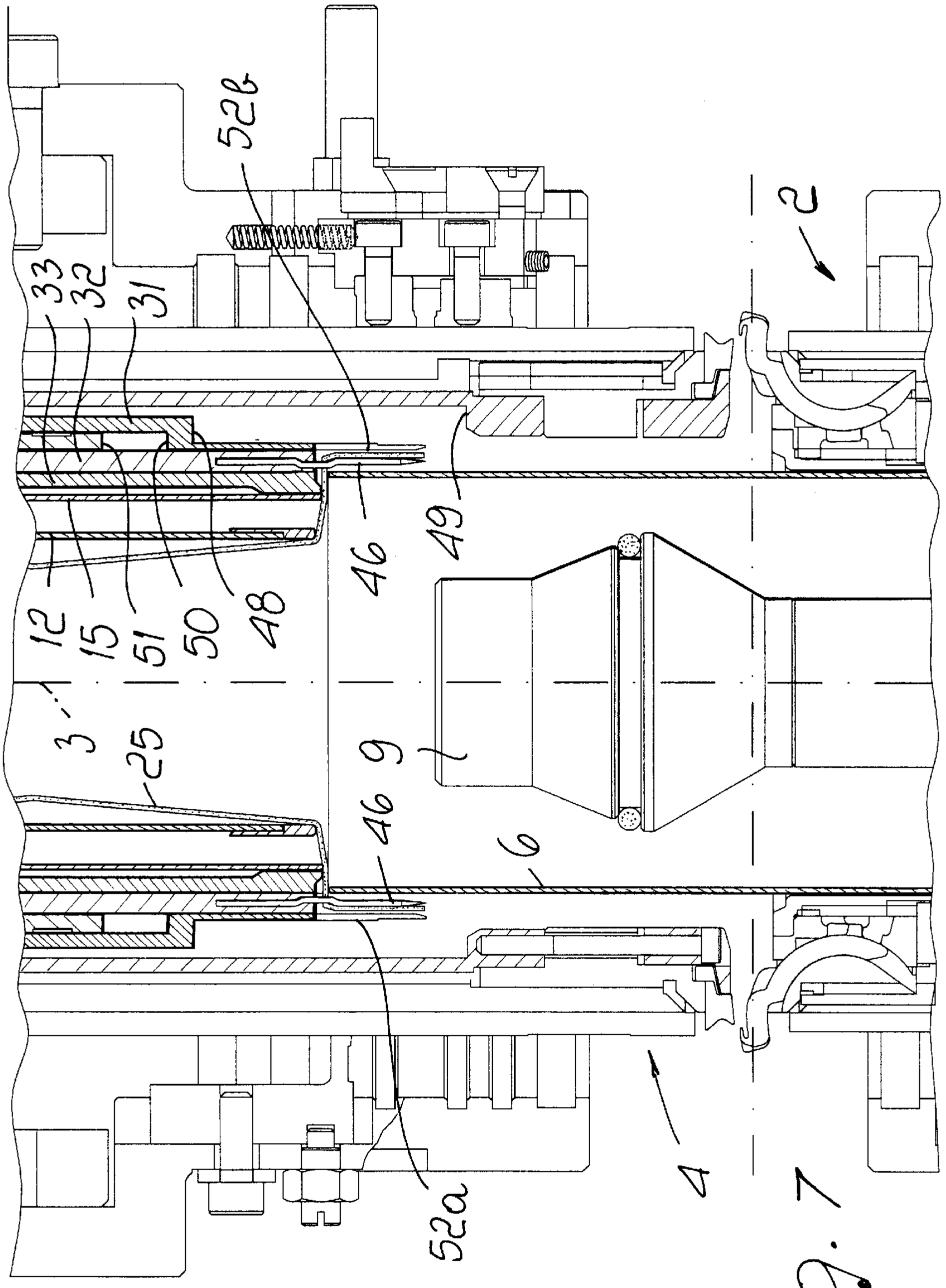
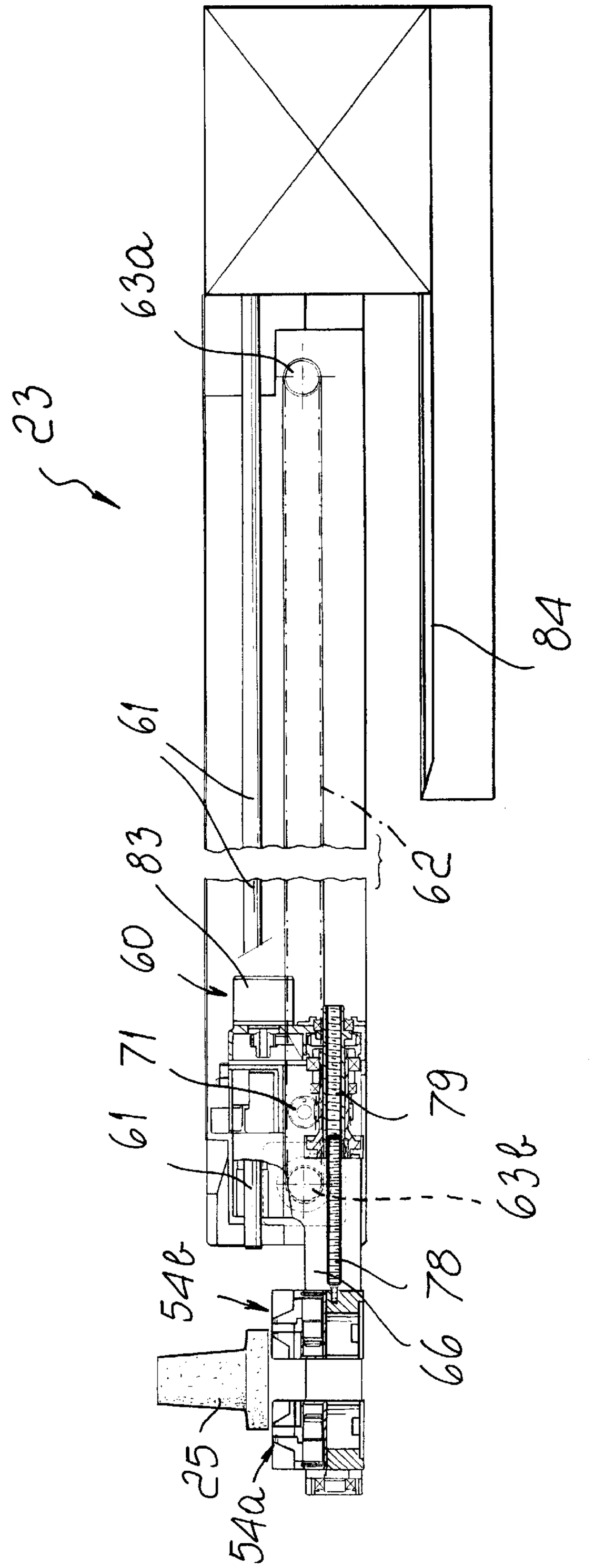


Fig. 1



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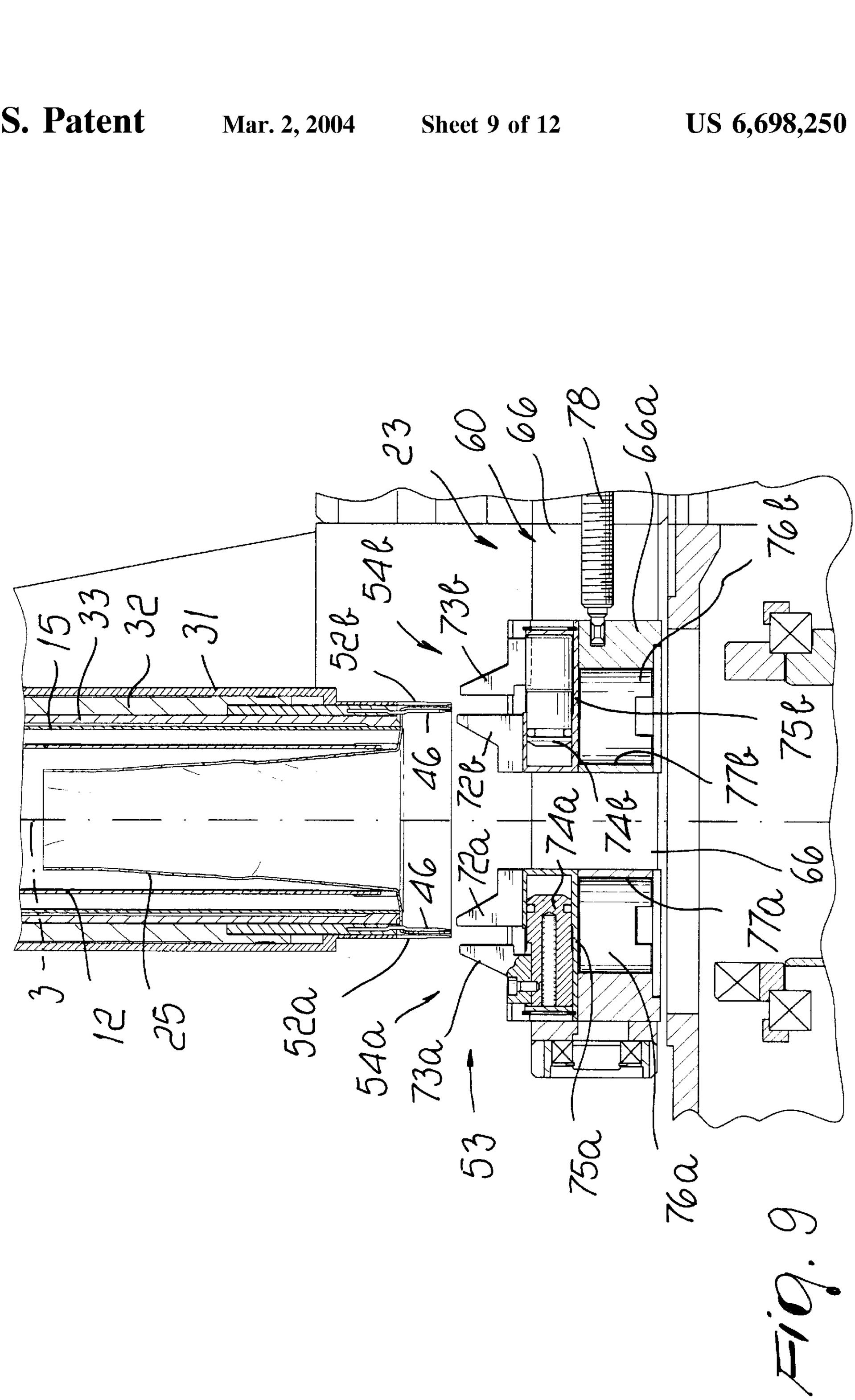
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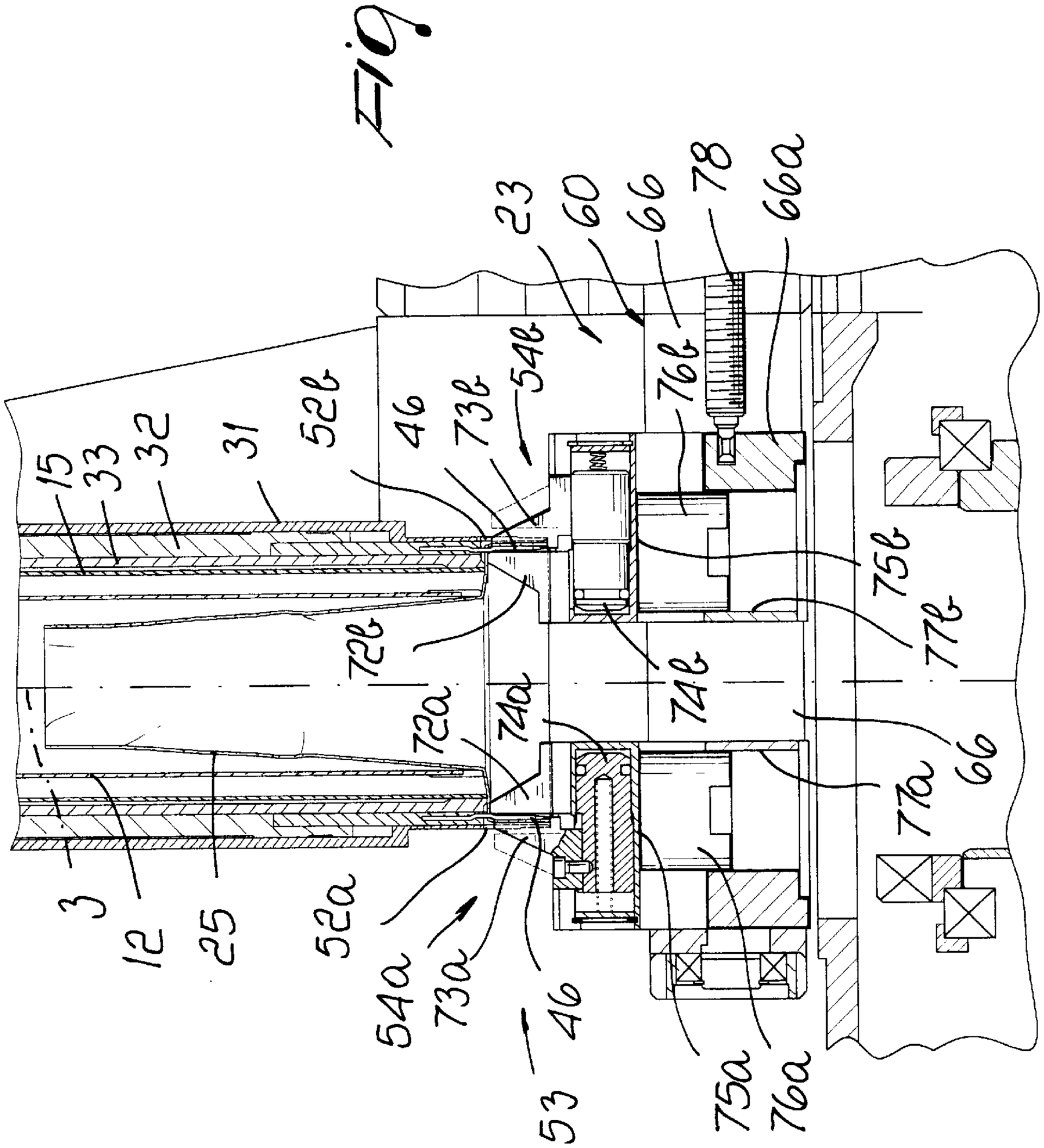
Fig. 9

Fig. 10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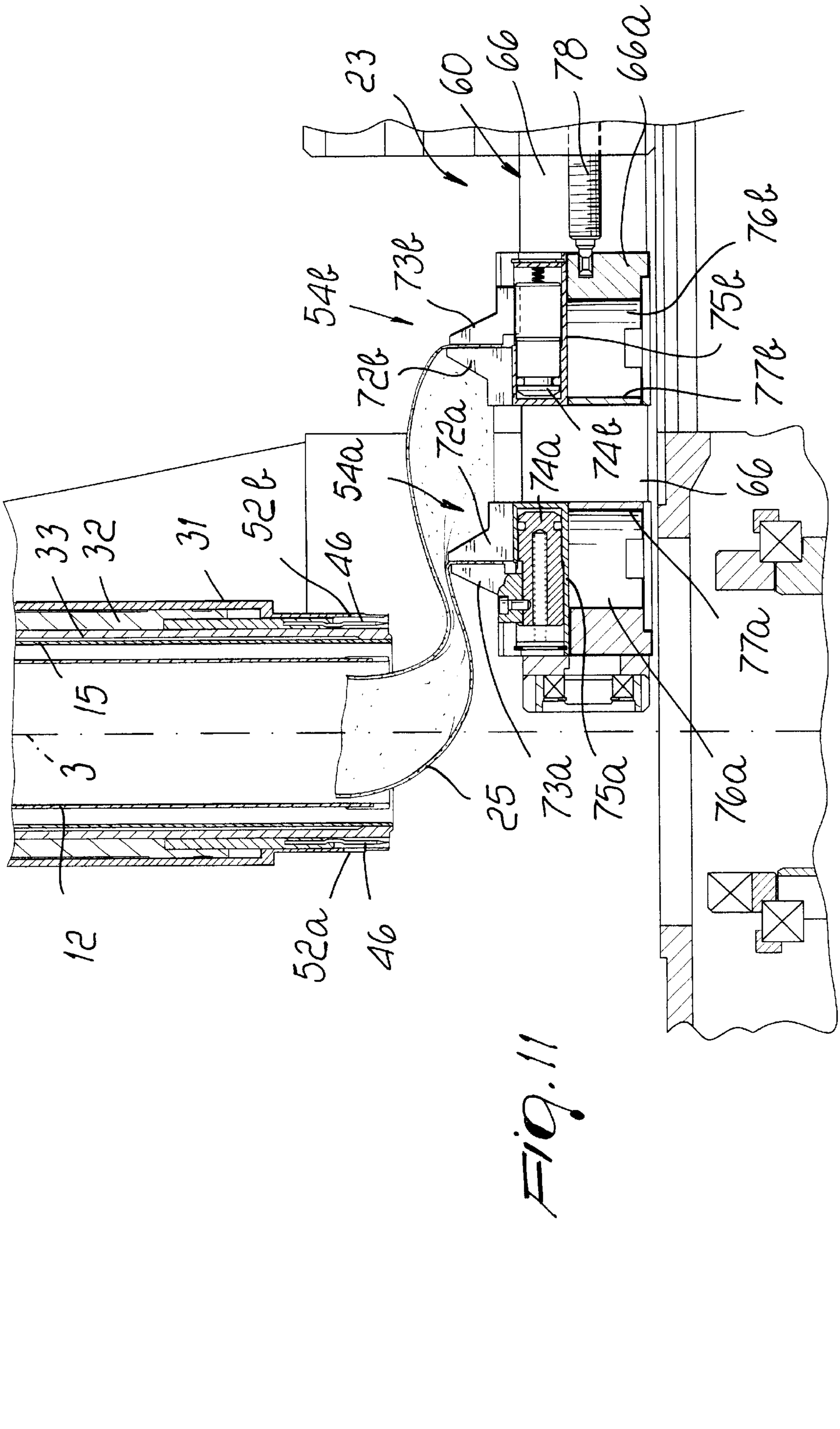
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Fig. 11

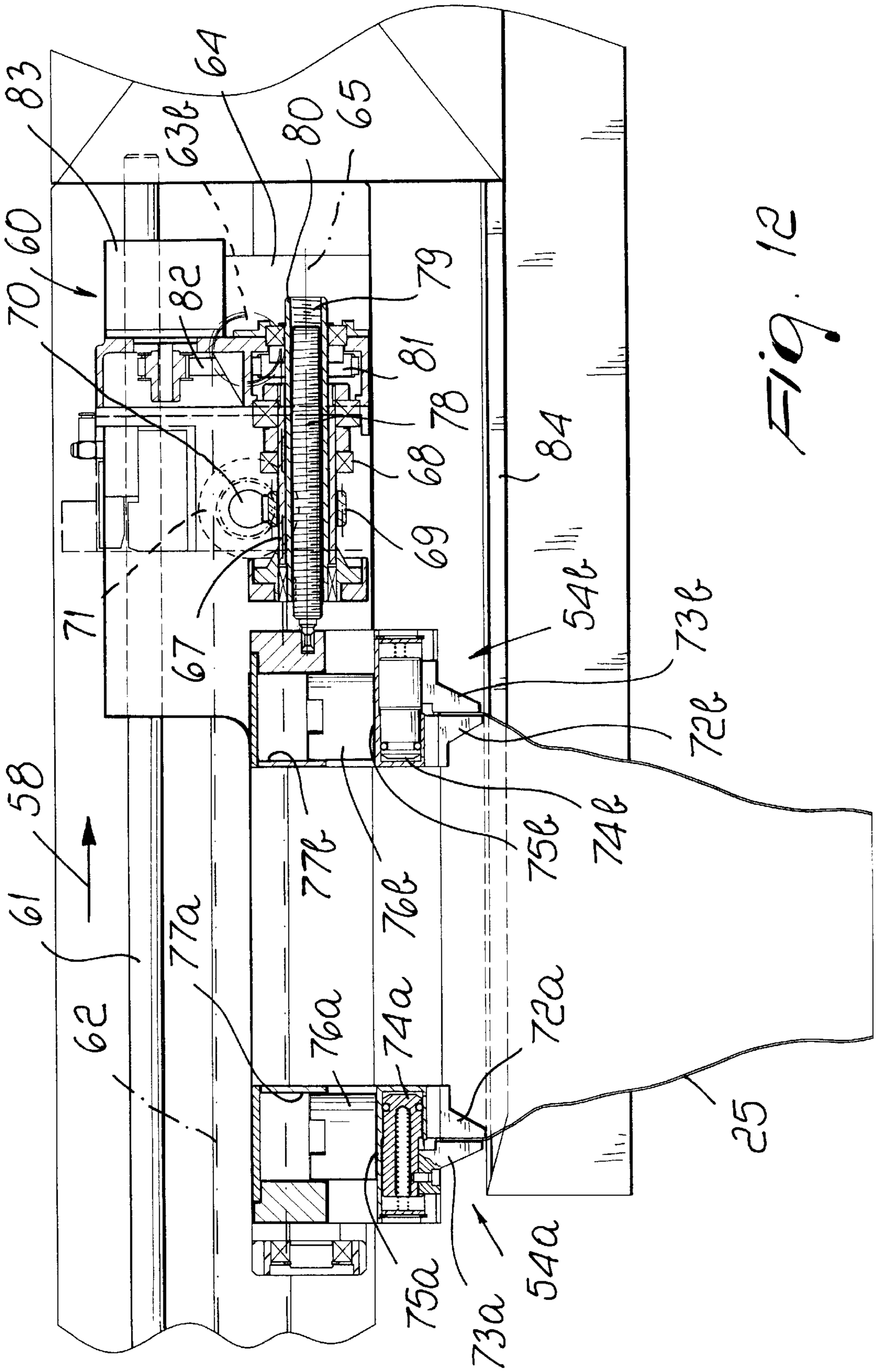
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Fig. 12

CIRCULAR KNITTING MACHINE WITH KNITTED ITEM REMOVAL/TRANSFERRING DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to a circular double-cylinder hosiery knitting machine with device for removing and transferring the article at the end of the knitting process, particularly for automating the closure of the toe of hosiery items.

As is known, according to conventional manufacturing processes tubular articles, particularly hosiery items, are generally manufactured by means of circular machines and are unloaded from the machine that manufactures them with both axial ends open. These articles must therefore be subjected to a subsequent sewing or looping operation, which closes one end of the article, constituted by the toe for hosiery items, in order to obtain the finished product.

Since this operation for closing an axial end of the article is an additional production step that requires time and the use of labor, with the associated costs, in recent years methods have been devised and perfected which seek to close one end of the article directly on the manufacturing machine or to automate the transfer of the article from the manufacturing machine to a sewing or looping machine, so as to reduce the overall manufacturing costs of the articles.

The methods that consist in closing an axial end of the article, directly on the manufacturing machine, have the drawback that they penalize considerably the production potential of the machine, since the time required to close the article is a time during which the machine cannot proceed with the production of other articles.

The methods that automate the transfer of the article from the manufacturing machine to a looping or sewing machine and therefore close an axial end of the article externally with respect to the manufacturing machine have the advantage that they allow, after removing the article from the manufacturing machine, to resume production on the part of the machine; therefore they penalize to a lesser extent the production potential of the machine. However, these methods still penalize significantly the productivity of the machine, since the removal of the article from the manufacturing machine still requires a certain time, which cannot be used for manufacturing.

SUMMARY OF THE INVENTION

The aim of the present invention is to solve the problems cited above, by providing a circular double-cylinder hosiery knitting machine with a device for removing and transferring the article at the end of the knitting process, particularly for automating the operation of closing the toe of hosiery items, which allows to reduce considerably the time taken away from the manufacturing of the machine, so as to not penalize, or penalize minimally, the productivity of the machine.

Within this aim, an object of the invention is to provide a circular double-cylinder hosiery knitting machine that allows to achieve correct closure of the toe of hosiery item even in the case of high-gauge hosiery items.

Another object of the invention is to provide a method for the automated transfer of a tubular article, particularly a hosiery item, from a circular double-cylinder machine to a sewing machine, which makes it economically convenient to perform this transfer.

Another object of the invention is to provide a circular double-cylinder hosiery knitting machine with a device for removing and transferring the article at the end of the knitting process that is highly reliable and precise in operation.

This aim and these and other objects that will become better apparent hereinafter are achieved by a circular double-cylinder hosiery knitting machine with a device for removing and transferring the article at the end of the knitting process, particularly for automating the closure of the toe of hosiery items, which comprises a lower needle cylinder, which has a vertical axis, and an upper needle cylinder, which is arranged above said lower needle cylinder and coaxially thereto, said needle cylinders being actuatable with a rotary motion about their own axis, characterized in that it comprises a device that is provided with a removal element that can be inserted from above into the upper needle cylinder and is provided with first grip means that can engage a region of the article being manufactured that is proximate to the final end of said article, said removal element being removable upwardly from the upper needle cylinder in order to move the article away from the machine, a transfer element being further provided which is arranged above the upper needle cylinder and is adapted to remove the article from said removal element and to feed it to a sewing machine in order to close said final end of the article.

BRIEF DESCRIPTION OF THE DRAWINGS

Further characteristics and advantages of the invention will become better apparent from the description of a preferred but not exclusive embodiment of the machine according to the invention, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

FIG. **1** is a schematic axial sectional view of the machine according to the invention, illustrating a part of the device for removing and transferring the article before said device begins working;

FIG. **2** is a schematic axial sectional view of the removal element in its operating position that corresponds to its complete insertion in the upper needle cylinder of the machine;

FIG. **3** is an enlarged-scale view of a detail of FIG. **1**;

FIG. **4** is a view of the detail of the machine shown in FIG. **2**, in a first step of the operation of the article removal element;

FIG. **5** is a view of the same detail of the machine shown in FIGS. **3** and **4**, in a second step of the operation of the removal element;

FIG. **6** is a view of the same detail of the machine in a third step of the operation of the removal element;

FIG. **7** is a view of the same detail of the machine shown in FIGS. **3** to **6**, with the removal element in a fourth step of operation;

FIG. **8** is a partially sectional lateral elevation view of the transfer element;

FIG. **9** is an enlarged-scale view of a detail of FIG. **8** in a first step of the operation of the transfer element;

FIG. **10** is a view of the same detail of FIG. **9**, in a second step of the operation of the transfer element;

FIG. **11** is a view of the same detail of FIGS. **9** and **10**, in a third step of the operation of the transfer element;

FIG. **12** is another view of the same detail of FIGS. **8** to **11**, in a fourth step of the operation of the transfer element.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to the figures, the circular double-cylinder hosiery knitting machine according to the invention, generally designated by the reference numeral **1**, comprises in a per se known manner a lower needle cylinder **2**, whose axis **3** is orientated vertically, and an upper needle cylinder **4**, which is arranged above the lower needle cylinder **2** and coaxially thereto.

The lower needle cylinder **2** and the upper needle cylinder **4** are supported by a supporting structure **5** so that they can rotate about the axis **3**, and they can be actuated, in a per se known manner, with a rotary motion about the axis **3**.

In a per se known manner, the lower needle cylinder **2** and the upper needle cylinder **4** contain a device for tensioning the article. Said article tensioning device comprises a lower suction tube **6**, referenced hereinafter as "lower tube" for the sake of brevity, which is arranged internally and coaxially with respect to the lower needle cylinder **2**. The lower tube **6** is rigidly coupled to the lower needle cylinder **2** in rotation about the axis **3** and can move on command along the axis **3** with respect to the lower needle cylinder **2**.

More particularly, the lower tube **6** is supported, so that it can slide axially, inside the lower needle cylinder **2** and is connected, proximate to its lower end, to the stem **7***a* of the piston of a pneumatic cylinder **7**, which is supported by the supporting structure **5** of the machine and is orientated so that one of its axes is parallel to the axis **3**. A bearing **8** is conveniently arranged between the stem **7***a* and the lower tube **6** in order to allow the rotation of the lower tube **6** about the axis **3**.

The stroke of the pneumatic cylinder **7** is such as to allow to move the lower tube **6** from a lowered position, in which its upper end lies directly below the upper end of the lower needle cylinder **2**, to a raised position, in which the lower tube **6** protrudes partly into the upper needle cylinder **4**, and vice versa.

A plug-like element **9** is accommodated internally and coaxially to the lower tube **6**. Said plug-like element **9** can move on command along the axis **3** with respect to the lower tube **6** and to the lower needle cylinder **2**. More particularly, the plug-like element **9** is fixed to the upper end of the stem **10***a* of the piston **10** of a pneumatic cylinder **11**, which is associated with the supporting structure of the machine.

The plug-like element **9** can move, by virtue of the action of the pneumatic cylinder **11**, along the axis **3** from an inactive position, in which it is fully accommodated within the lower needle cylinder **2** and is spaced downward from the upper end of said lower needle cylinder **2**, to an active position, in which it engages the lower end of an upper suction tube **12**, referenced hereinafter as "upper tube" for the sake of brevity, which is accommodated in the upper needle cylinder **4**, as will become better apparent hereinafter.

The piston **10** of the pneumatic cylinder **11** can move upward in contrast with a spring **13** that actuates the descent of the plug-like element **9** when the pneumatic cylinder **11** is discharged.

The upper tube **12**, which is also part of the article tensioning device, is arranged above the upper needle cylinder **4** and coaxially thereto and protrudes with its lower end into the upper needle cylinder **4**.

A tensioning tube **15** is arranged around the upper tube **12** and can move on command, in a per se known manner, along the axis **3** in order to pass from a raised position, in which its lower end is level with, or arranged above, the lower end

of the upper needle cylinder **4**, to a lowered position, in which its lower end protrudes inside the lower needle cylinder **2** around the plug-like element **9**.

The movement of the tensioning tube **15** can be actuated, in a per se known manner, by way of a pneumatic device, generally designated by the reference numeral **16**, which is substantially constituted by a pneumatic cylinder **17**, which is provided with a piston **18**, which is in turn connected, at its axial ends, to the ends of a cable or belt **19**. The cable or belt **19** winds around two pulleys **20***a* and **20***b*, which have horizontal axes, so that one portion of said cable, which runs between the pulleys **20***a* and **20***b*, is arranged vertically laterally to the tensioning tube **15**. Said portion is connected, with the interposition of a bearing **21**, to the tensioning tube **15** so that the actuation of the pneumatic cylinder **17** causes the upward or downward axial translational motion of the tensioning tube **15**.

The lower tube **6** can be connected on command, in a per se known manner, to suction means, and likewise the upper tube **12** can be connected to suction means in order to generate, when required, a partial vacuum inside said tubes **6** and **12**.

The double-cylinder knitting machine is not described further, since it can be constituted by a circular double-cylinder knitting machine of a known type with a fabric tensioning device. For example, the machine can be constituted by a double-cylinder machine of the type disclosed in U.S. Ser. No. 08/595,112 by the same Applicant.

The machine according to the invention comprises a device for removing and transferring the article at the end of the knitting process.

Said removal and transfer device comprises a removal element, generally designated by the reference numeral **22**, and a transfer element, generally designated by the reference numeral **23**.

The removal element **22** can be inserted from above into the upper needle cylinder **4** and is provided with first grip means **24**, which can engage a region of the article **25** being manufactured that is proximate to the final end of said article **25** and can be extracted upwardly from the upper needle cylinder **4** in order to move the article **25** away at the end of its knitting.

The transfer element **23** is arranged above the upper needle cylinder **4**, and is adapted to remove the article **25** from the removal element **22** and feed it to a sewing machine that is capable of closing the final end of the article **25**, as will become better apparent hereinafter.

The removal element **22** includes internally the upper tube **12**, which as mentioned can be connected on command to suction means to form aspirating means. In this manner, the removal element **22** comprises means for aspirating the article **25** that allow to aspirate the article **25** upward inside said upper tube **12**, so as to arrange the article **25** upside down.

The removal element **22** substantially comprises a hollow outer cylinder **31** ("outer cylinder" for the sake of brevity), a hollow intermediate cylinder **32** ("intermediate cylinder" for the sake of brevity), and a hollow inner cylinder **33** ("inner cylinder" for the sake of brevity), which are coaxial and are supported by a supporting structure **34** so that they can rotate about their own axis, which coincides with the axis **3**. Said supporting structure **34** is substantially composed of an upper head **35** and a lower head **36**, which are connected to each other by vertical rods, not shown in the figures, and by a housing **26**, which surrounds the upper part of the removal element **22**. The upper head **35** and the lower

head **36** are slidingly supported by vertical guiding columns **37**, which are fixed to the supporting structure of the machine above the upper needle cylinder **4**.

The inner cylinder **33** is rigidly coupled to the inner tube **12** and is supported, together with said inner tube, so as to allow rotation about the axis **3**, by the upper head **35**, by interposing a bearing **14**, and by the lower head **36**, by interposing a bearing **38**. The upper head **35** is connected to the stem **39***a* of a pneumatic cylinder **39**, which is fixed by means of its body to a block **40** that is rigidly coupled to one of the guiding columns **37** and is arranged so that its axis is parallel to the axis **3**. By actuating the pneumatic cylinder **39**, i.e. on command, the assembly constituted by the outer cylinder **31**, the intermediate cylinder **32** and the inner cylinder **33**, and by the upper tube **12** and the tensioning tube **15** together with its actuation device **16**, is made to perform a translational motion along the axis **3**.

Said assembly constituted by the three cylinders **31**, **32** and **33** can be connected, in its rotation about the axis **3**, to the upper needle cylinder **4**. More particularly, the inner cylinder **33** is provided with a flange **41**, which protrudes outside the intermediate cylinder **32** and the outer cylinder **31** and to which a tooth **42** is fixed which, when the removal element **22** is inserted in the upper needle cylinder **4**, engages in a seat **43**a provided, in a specific angular position around the axis **3**, in a flange **43** that is rigidly coupled to the upper needle cylinder **4**.

The cylinders **31**, **32** and **33** are jointly coupled, in rotation about the axis **3**, by using tabs or rotational couplings of another kind, which are only partially visible in the figures. Furthermore, the intermediate cylinder **32** can move axially with respect to the inner cylinder **33**. More particularly, the intermediate cylinder **32** has, at its upper end, at least one extension **32***a*, which passes through suitable passages formed in the flange **41** and is fixed to the inner ring of a bearing **44**.

The outer ring of the bearing **44** is connected to the stem **45***a* of the piston of a pneumatic cylinder **45**, which is arranged so that its axis is parallel to the axis **3** and is mounted on the supporting structure **34**. The first grip means **24** comprise punches **46**, which are fixed to the lower end of the intermediate cylinder **32** and are orientated so that their tip is directed downward.

The actuation of the pneumatic cylinder **45**, that constitutes actuation means for the intermediate cylinder, causes the translational motion, along the axis **3**, of the intermediate cylinder **32** with respect to the inner cylinder **33** in order to achieve its passage from an inactive position, in which the punches **46** are arranged so that their tip is at a higher level than the lower end of the inner cylinder **33**, to an active position, in which the punches **46** are arranged so that their tip lies below the lower end of the inner cylinder **33** in order to engage them with the article **25**, as will become better apparent hereinafter.

The outer cylinder **31** can move axially with respect to the intermediate cylinder **32** in order to pass from a raised position, in which it is arranged with its lower end substantially at the level of the tip of the punches **46**, to a lowered position, in which it is arranged so that its lower end lies below the lower end of the punches **46**.

Elastic means are interposed between the intermediate cylinder **32** and the outer cylinder **31** and are constituted, in the illustrated embodiment, by spring-loaded pistons **47**, which contrast the passage of the outer cylinder **31** from the lowered position to the raised position.

It should be noted that the outer cylinder **31** has, on its cylindrical wall, an axial shoulder **48** which, when the removal element **22** is inserted in the upper needle cylinder **4**, is designed to rest against an abutment **49** provided correspondingly on the inner cylindrical wall of the upper needle cylinder **4**. Said outer cylinder **31** is further provided, on its inner cylindrical wall, with an abutment **50** that is adapted to be engaged by an axial shoulder **51** provided on the outer cylindrical wall of the intermediate cylinder **32** in order to delimit the downward stroke of the intermediate cylinder **32** when the removal element **22** is accommodated inside the upper needle cylinder **4**.

The first grip means **24** comprise at least two pairs of grip elements, which can engage two diametrically opposite regions of the article **25**. The grip elements of a same pair are spaced one another, so as to leave a portion of the article **25** free between the two grip elements of a same pair.

In the illustrated embodiment, in which the first grip means are constituted by the punches **46**, there are at least two pairs of punches, which are arranged in two diametrically opposite regions at the lower end of the intermediate cylinder **32**. The punches of a same pair are spaced one another so as to leave free a portion of the article **25** between the two punches of a same pair. Furthermore, the outer cylinder **31** has, at these regions, two passages **52***a* and **52***b*, which are arranged in two diametrically opposite regions starting from the lower end of the outer cylinder **31**, so as to allow second grip means **53** of the transfer element **23**, described in greater detail hereinafter, to act on the article **25**.

Conveniently, first means are provided for locking the article **25** before it is engaged by the first grip means **24**. Said first locking means can engage a region of the article **25** that is closer to the axis of the article **25** than the region that can be engaged by the first grip means **24**.

More particularly, the first locking means cited above comprise the plug-like element **9**, which by way of the actuation of the piston **10** of the pneumatic cylinder **11** can engage the lower end of the upper tube **12**, while the article **25** is aspirated into said upper tube so as to lock said article **25**.

The plug-like element **9**, again thanks to its ability to move axially by actuation of the pneumatic cylinder **11**, can follow at least partially or move jointly with the removal element **22** during its upward motion when the removal element **22** is extracted from the upper end of the upper needle cylinder **4**.

Advantageously, there are also second means for locking the article **25** before it is engaged by the first grip means **24**. Said second locking means can engage a region of the article **25** that is located between the region that can be engaged by the first grip means **24** and the region that can be engaged by the first locking means.

Said second locking means comprise the lower tube **6**, which thanks to its ability to perform a translational motion along the axis **3**, actuated by way of the pneumatic cylinder **7**, can engage against the lower end of the inner cylinder **33**.

The lower end of the inner cylinder **33** is conveniently shaped so as to allow effective locking of the article **25** on the part of the upper end of the lower tube **6**.

It should be noted that the lower end of the inner cylinder **33** can be shaped in a different manner along its circumferential extension, so as to allow correct engagement of the article **25** between the inner cylinder **33** and the lower tube **6** despite the presence of various shaped portions of the article **25** along its circumferential extension. For example, in the case of hosiery items, it is possible to provide a different shape of the lower end of the inner cylinder **33**, so

as to allow to grip the article correctly even in regions, for example at the toe, where there is an excess of knitting.

The lower tube **6**, by virtue of the action of the pneumatic cylinder **7**, can follow at least partially or move jointly with the removal element **22** during its upward motion when it is extracted upward from the upper needle cylinder **4**, so as to maintain the locking of the article **25** at least along part of said upward motion.

As mentioned, the removal element **22**, particularly the assembly constituted by the outer cylinder **31**, the intermediate cylinder **32**, and the inner cylinder **33**, can be coupled, in rotating about the axis **3**, to the upper needle cylinder **4** by way of the coupling of the tooth **42** within the seat **43***a* in a preset angular position about the axis **3**. This assuredly allows engagement of the punches **46** with specific regions of the article that substantially correspond to the lateral ends of the opening of the article to be closed through the subsequent sewing operation. In the case of hosiery items, said regions are constituted by the ends of the opening of the toe to be closed.

In order to allow the correct coupling of the tooth **42** with the seat **43***a* and allow correct positioning of the removal element **22** with respect to the transfer element **23**, there are means for actuating the removal element **22** with a controlled rotary motion about the axis **3** with respect to the supporting structure **34**. Said actuation means comprise a motor **55**, which is mounted on the supporting structure **34** and is connected, by way of its output shaft, to a gear **56**, which is keyed on an extension of the inner cylinder **33**. The motor **55** is a motor of the electric type, for example a step motor or a brushless motor, in which the angular rotation can be controlled, and said motor can be optionally connected, by means of an electronic control system of the axis-following type, to the motor for actuating the needle cylinders **2** and **4** so as to assuredly achieve, during the insertion of the removal element **22** in the upper needle cylinder **4**, an alignment of the tooth **42** with the seat **43***a*. The angular position of the inner cylinder **33** and therefore of the entire assembly constituted by the cylinders **31**, **32** and **33** can also be controlled directly by means of a known type of sensor **57**.

The number of punches **46** can vary according to the requirements, but without changing the presence of two pairs of punches that can engage two diametrically opposite regions of the article **25**. As an extreme option, it is possible to provide a ring of punches **46** that runs all around the axis **3**, although, as shown, a smaller number of punches **46** is sufficient to keep free from the article **25** the regions of said article that have to be engaged by the second grip means **53**, i.e., the regions located between the punches of the two pairs of punches that can engage two mutually diametrically opposite regions of the article **25**.

The transfer element **23** can move on command, i.e. upon selective and purposely actuation, along a substantially horizontal transfer direction **58** from a position for gripping the article **25**, in which it is arranged with the second grip means **53** below the lower end of the removal element **22** in the position in which it is extracted upwardly from the upper needle cylinder **4**, to a transfer position, in which it is moved laterally away from the upper needle cylinder **4**, and vice versa.

More particularly, the transfer element **23** is mounted on a supporting structure **60**, which is in turn mounted so that it can slide on horizontal guiding bars **61**. The supporting structure **60** is further fixed to the portion of a toothed belt **62** that winds around a pair of pulleys **63***a* and **63***b* that have horizontal and mutually parallel axes. One of these pulleys, the pulley **63***b* in the illustrated embodiment, is connected to the output shaft of an electric motor, which can be actuated in order to produce the sliding, in one direction or in the opposite direction, of the supporting structure **60** along the guiding bars **61**.

Furthermore, the supporting structure **60** is formed by multiple parts that move with respect to each other. More particularly, the supporting structure **60** is composed of a sliding element **64**, which can only perform a translational motion along the guiding bars **61** and is fixed to the portion of the belt **62**. The sliding element **64** supports, so that it can rotate about a horizontal axis **65**, a supporting element **66**, which supports the second grip means **53**. Said supporting element **66** is provided with a sleeve **67**, whose axis coincides with the axis **65** and is supported, by interposing bearings **68**, so that it can rotate about the axis **65** on the part of the sliding element **64**. A pinion **69** is keyed on said sleeve **67**, and a rack **70** engages therewith and is actuated by means of a pneumatic actuator **71**. The actuation of said pneumatic actuator **71** causes the rotation of the supporting element **66**, and therefore of the second grip means **53**, about the axis **65** in order to overturn the article **25**, which is engaged by the second grip means **53**, as will become better apparent hereinafter.

The second grip means **53** of the transfer element **23** comprise two grippers, respectively a first gripper **54***a* and a second gripper **54***b*, which are mounted on said supporting element **66** and can move together with it along the guiding bars **61**.

Furthermore, the two grippers **54***a* and **54***b* can also move along a substantially vertical direction with respect to the supporting element **66**, so as to enter with a jaw of each one of the grippers through the lower end of the outer cylinder **31**.

The inner or first jaw **72***a* of the first gripper **54***a* is fixed to the supporting element **66**, so as to perform a translational motion rigidly therewith along the transfer direction **58**, while the other or second jaw **73***a* of said first gripper **54***a* is connected to the piston **74***a* of a pneumatic cylinder **75***a*, which can be actuated to move the jaw **73***a* toward or away from the jaw **72***a*.

Likewise, the second gripper **54***b* is also constituted by a first jaw **72***b*, is which is rigidly coupled, in translational motion along the transfer direction **58**, to a portion **66***a* of the supporting element **66**. The other, second jaw **73***b*, in this second gripper **54***b*, is connected to the piston **74***b* of a pneumatic cylinder **75***b*, which can be actuated to move the jaw **73***b* toward or away from the jaw **72***b*. The jaws **72***a* and **73***a* of the first gripper, together with the pneumatic cylinder **75***a* that actuates the jaw **73***a*, are in turn mounted on the piston **76***a* of another pneumatic cylinder **77***a*, which has a vertical axis and can be actuated in order to lift and lower the first gripper **54***a*. The body of this pneumatic cylinder **77***a* is formed directly in the supporting element **66**.

Likewise, the jaws **72***b* and **73***b* of the second gripper **54***b* are in turn mounted, together with the pneumatic cylinder **77***b* that actuates the jaw **73***b*, on the piston **76***b* of another pneumatic cylinder **77***b*, which has a vertical axis and can be actuated so as to lift and lower said second gripper **54***b*. The pneumatic cylinder **77***b* that actuates said lowering and lifting of the second gripper **54***b* is provided in the portion **66***a* of the supporting element **66**.

The portion **66***a* is associated, so that it can slide along a direction that is parallel to the transfer direction **58**, with the supporting element **66**, and is connected, by means of a

threaded shaft **78**, whose axis is horizontal and parallel to the transfer direction **58**, to a female thread **79** that is formed in a bush **80** that is inserted coaxially in the sleeve **67**. The bush **80** is locked axially and can rotate within the sleeve **67**, which is rigidly coupled to the pinion **69**. The bush **80** is rigidly coupled to a toothed pulley **81**, which is connected, by means of a toothed-belt connection **82**, to the output shaft of an electric motor **83**, which can be actuated in order to turn the bush **80** about the axis **65**. This rotation of the bush **80** causes, as a consequence of the threaded coupling with the shaft **78**, a translational motion of the portion **66***a* of the supporting element **66** and therefore of the second gripper **54***b* with respect to the first gripper **54***a* parallel to the transfer direction **58**. The movement of the second gripper **54***b* with respect to the first gripper **54***a*, parallel to the transfer direction **58**, has the effect of causing the article **25** to widen when it is engaged with the grippers **54***a* and **54***b*, and therefore of flattening the region of the article **25** that is engaged by said grippers, as will become better apparent hereinafter.

The transfer element **23** is arranged, along at least one portion of its path along the transfer direction **58**, above a feeder guide **84** of a sewing machine, of a known type which is shown only partially for the sake of simplicity, so as to actuate, during its translational motion laterally away from the double-cylinder machine, the insertion of the axial end of the article **25** to be sewn in said feeder guide **84**.

The operation of the machine with a device for removing and transferring the article at the end of the knitting process according to the invention is as follows.

For the sake of greater clarity, the operation of the machine according to the invention is described with reference to the production of a hosiery item, without altering the fact that the machine can also be used to manufacture other articles meant to be closed at one of their axial ends.

The hosiery item is produced starting from the top, i.e., from its axial end that lies opposite the axial end or toe to be closed by sewing.

Furthermore, it should be noted that the hosiery item, as usually occurs in conventional manufacturing processes, is finished at the toe by forming a few rows of stitches, or border, that are meant to be removed during sewing and are formed indeed to allow the precise and correct insertion of the toe to be sewn in the feeder guide **84** of a sewing machine.

While the machine is completing the knitting of the article **25**, the removal element **22** is inserted and coupled to the upper needle cylinder **4** in its rotation about the axis **3**.

The article **25** is aspirated into the upper tube **12** and is therefore upside down (FIG. **3**).

Preferably, while the machine is completing the knitting of the last rows of stitches, the plug-like element **9** is moved, by way of the actuation of the pneumatic cylinder **11**, so that it engages the lower end of the upper tube **12**, thus locking the article **25**. It should be noted that this operation can also be performed in a preceding step, if the intervention of the article tensioning device constituted by the plug-like element **9**, the upper tube **12** and the tensioning tube **15** is required.

Then the pneumatic cylinder **7** is actuated, lifting the lower tube **6**, which by engaging the lower end of the inner tube **33** produces a further locking of the article **25** (FIG. **4**). At this point, the pneumatic cylinder **45** is actuated, causing the descent of the intermediate cylinder **32** and therefore the passage of the punches **46** through the article **25** (FIG. **5**).

It should be noted that the passage of the punches **46** through the article **25** occurs while the article **25** is locked by the plug-like element **9**, by the upper tube **12**, and between the inner cylinder **32** and the lower tube **6** and while the article **25** is still engaged by the needles of the machine. In this manner, the punches **46** assuredly pass through the article **25**. The descent of the intermediate cylinder **32** is limited by the abutment **50** of the outer cylinder **31**, which in turn rests against the abutment **49**. The descent of the intermediate cylinder **32** loads the spring-loaded pistons **47** that are interposed between the intermediate cylinder **32** and the outer cylinder **31**.

At this point, the needles of the machine have ended the manufacture of the article **25** and release the last formed row of stitches. Then the pneumatic cylinder **39** is actuated and starts to extract the removal element **22** upwardly from the upper needle cylinder **4**. For part of the upward motion of the removal element **22**, the lower tube **6** follows the removal element **22**, keeping the article **25** locked. Likewise, for part of the upward motion, the plug-like element **9** follows the removal element **22**, also keeping the article **25** locked in the upper tube **12**.

It should be noted that at the beginning of the upward motion of the removal element **22** the outer cylinder **31** is kept against the abutment **49**, by way of the action of the spring-loaded pistons **47**, while the remaining part of the removal element **22** is rising. For this reason, the lower end of the outer cylinder **31** gradually descends below the tip of the punches **46**, bending downward the rim of the article **25** that lies outside the punches **46** and protecting said rim from contact with other elements of the machine during its extraction (FIGS. **6** and **7**).

The upward motion of the removal element **22** continues until the removal element **22** is fully extracted upward from the upper needle cylinder **4**. It should be noted that the disengagement of the removal element **22** from the upper needle cylinder **4** and the disengagement of the plug-like element **9** from the upper tube **12** have the effect of disengaging these two elements in rotation about the axis **3**; therefore, once the removal element **22** has been extracted upwardly from the upper needle cylinder **4**, it can be in any angular position around the axis **3**. For this reason, the motor **55** is actuated, arranging the removal element **22** in a preset angular position around the axis **3**. Said preset angular position is such as to move the passages **52***a* and **52***b* of the outer cylinder **31** into alignment with the grippers **54***a* and **54***b* mounted on the transfer element **23**.

At this point, the grippers **54***a* and **54***b*, by way of the actuation of the belt **62**, are arranged below the lower end of the removal element **22**, with the jaws **73***a* and **73***b* spaced from the jaws **72***a* and **72***b* (FIGS. **8** and **9**). The grippers **54***a* and **54***b*, previously in the lowered position, are raised by way of the actuation of the pistons **76***a* and **76***b* of the cylinders **77***a* and **77***b* so as to insert the jaws **72***a* and **72***b* in the article **25**.

Then the pistons **74***a* and **74***b* of the cylinders **75***a* and **75***b* are actuated, moving the jaws **73***a* and **73***b* toward the jaws **72***a* and **72***b*, gripping the regions of the article that are located at the passages **52***a* and **52***b* (FIG. **10**).

At this point, by way of the actuation of the pistons **76***a* and **76***b* of the cylinders **77***a* and **77***b*, the grippers **54***a* and **54***b* are lowered and at the same time the intermediate cylinder **32**, by way of the actuation of the pneumatic cylinder **45**, is lifted together with the outer cylinder **31**, so that the article **25** disengages assuredly from the removal element **22** and remains anchored to the grippers **54***a* and **54***b*.

The grippers **54***a* and **54***b*, by way of the actuation of the belt **62**, are moved away, along the transfer direction **58**,

laterally to the machine, actuating the extraction of the article **25** from the upper tube **12** (FIG. **11**).

Once the article **25** has been removed by the grippers **54***a* and **54***b*, the removal element **22** is lowered again and inserted in the upper needle cylinder **4**, coupling to the tooth **42** in the seat **43***a*. The tooth **42** is positioned correctly with respect to the seat **43***a* by way of the actuation of the motor **55**.

During this movement of the grippers **54***a* and **54***b* away from the machine, the rack **70** is also actuated and, by causing the rotation of the grippers **54***a* and **54***b* about the horizontal axis **65**, turns over the article **25**, orientating it so that the border, i.e., the end to be sewn, is directed upward. At the same time, or in any case during the movement of the transfer element **23** along the guiding bars **61** away from the double-cylinder machine, the motor **83** is also actuated and, by causing the rotation of the bush **80**, causes the movement of the second gripper **54***b* away from the first gripper **54***a*, tensioning the article **25** at the region gripped by the grippers **54***a* and **54***b* and thus causing its flattening, with mutual movement of the two flaps of the border stretched between said grippers.

In the final portion of the translational motion of the transfer element **23** along the guiding bars **61**, the article **25** is inserted, with its portion proximate to the end gripped by the grippers **54***a* and **54***b*, into the feeder guide **84** of the sewing machine (FIG. **12**).

At this point, the article **25** is released by the grippers **54***a* and **54***b* and its advancement along the feeder guide **84** of the sewing machine is performed by way of means of a known type with which the sewing machine is provided and which are not described for the sake of brevity.

It should be noted that after the lower tube **6**, together with the plug-like element **9**, has been returned into the lower needle cylinder **2**, i.e., while the removal element **22** is still completing the extraction of the article **25** from the upper needle cylinder **4**, the machine can resume knitting, starting to form a new article. The article being manufactured in this step can be tensioned by applying suction to the lower tube **6**.

In this manner, the time during which the machine is not manufacturing is reduced significantly with respect to the unproductive times that can be observed in currently commercially available machines capable of performing the automated transfer of articles from the manufacturing machine to a sewing machine in order to close an axial end of the articles.

In practice it has been found that the machine with device for removing and transferring the article at the end of the knitting process according to the invention fully achieves the intended aim, since by reducing considerably the time during which the machine is unable to manufacture an article due to the transfer of the previously manufactured article, it is not penalized or is penalized to a minimal extent as regards its productivity.

The machine with device for removing and transferring the article thus conceived is susceptible of numerous modifications and variations, all of which are within the scope of the appended claims; all the details may further be replaced with other technically equivalent elements.

In practice, the materials used, as well as the dimensions, may be any according to requirements and to the state of the art.

The disclosures in Italian Patent Application No. MI2002A001384 from which this application claims priority are incorporated herein by reference.

What is claimed is:

1. A circular double-cylinder hosiery knitting machine comprising: a lower needle cylinder, which has a vertical axis; an upper needle cylinder, which is arranged above said lower needle cylinder and coaxially thereto, said needle cylinders being actuatable with a rotary motion about said vertical axis; and a device for removing and transferring a knitted article, said removing and transfer device being provided with a removal element that is insertable from above into the upper needle cylinder and being removable upwardly from the upper needle cylinder in order to move the article away from the machine, said removal element having first grip means for engaging a region of the article being manufactured that is proximate to a final end of the article, and with a transfer element which is arranged above the upper needle cylinder to remove the article from said removal element and to feed the removed article to a sewing machine in order to close the final end of the article.

2. The machine of claim **1**, wherein said removal element comprises aspiration means for aspirating the article upward and for arranging the article upside down, inside the upper needle cylinder, before engagement of the final end of the article by way of said first grip means.

3. The machine of claim **2**, wherein said first grip means comprise at least two pairs of grip elements for engaging two mutually diametrically opposite regions of the article, grip elements of a same pair being mutually spaced in order to leave a portion of the article free between two grip elements of a same pair, said transfer element being provided with second grip means for engaging the free portion of the article located between two grip elements of a same pair of grip elements.

4. The machine of claim **2**, wherein said removal element is insertable in said upper needle cylinder and coupleable thereto for rotation about said vertical axis thereof; said removal element being rotationally coupleable with said upper needle cylinder in a preset angular position about the vertical axis of the needle cylinders with respect to an angular position of said upper needle cylinder.

5. The machine of claim **3**, further comprising first locking means for locking the article on said removal element before engagement thereof by way of said first grip means, said first locking means being adapted to engage a region of the article that is closer to said vertical axis than a region that is engaged by said first grip means.

6. The machine of claim **5**, further comprising second locking means for locking the article on said removal element before engagement thereof by said first grip means, said second locking means being adapted to engage a region of the article that is located between the region that is engaged by said first grip means and the region that is engaged by said first locking means.

7. The machine of claim **6**, wherein said removal element comprises a hollow inner cylinder, a hollow intermediate cylinder, and a hollow outer cylinder all of which have a vertical axis; said hollow inner, intermediate and outer cylinders being coaxial and being insertable and extractable on command coaxially in and from said upper needle cylinder.

8. The machine of claim **7**, wherein said hollow inner, intermediate and outer cylinders are coupled to each other for joint rotation about said vertical axis.

9. The machine of claim **5**, wherein said first grip means comprise punches that are connected to a lower axial end of said hollow intermediate cylinder and are directed with tips thereof downward, cylinder actuation means being provided for actuating said hollow intermediate cylinder along said vertical axis with respect to said hollow inner cylinder in order to move the intermediate cylinder from an inactive position, in which said punches are arranged with the tips thereof at a higher level than a lower axial end of said hollow

inner cylinder, to an active position, in which said punches are arranged with the tips thereof below a lower axial end of said hollow inner cylinder in order to engage the article, and vice versa.

10. The machine of claim **9**, wherein said hollow outer cylinder is movable axially with respect to said hollow intermediate cylinder in order to pass from a raised position, in which a lower axial end thereof is substantially at a level of the tips of said punches, to a lowered position, in which the lower axial end lies below the tips of said punches, elastic means being provided between said intermediate and outer cylinders which contrast passage of said hollow outer cylinder from said lowered position to said raised position.

11. The machine of claim **2**, wherein said aspiration means for aspirating the article upward comprises an upper suction tube, which is arranged internally and coaxially to said hollow inner cylinder.

12. The machine of claim **6**, wherein said first locking means comprise a plug element that is arranged coaxially to said needle cylinders; said plug element being movable, on command, along the axis of the needle cylinders from an inactive position, in which said plug element is accommodated in said lower needle cylinder and is spaced downward from a lower end of said upper suction tube, to an active position, in which the plug engages a lower end of said upper suction tube in order to lock said article between said upper suction tube and said plug element.

13. The machine of claim **12**, wherein said plug element is at least partially movable axially and jointly with said removal element in order to maintain locking of the article at least along part of an upward motion of said removal element.

14. The machine of claim **10**, wherein said second locking means comprise a lower suction tube, which is accommodated coaxially in said lower needle cylinder and is movable axially with respect to the lower needle cylinder in order to engage or disengage a lower end of said hollow inner cylinder in order to lock the article between the lower end of said hollow outer cylinder and an upper end of said lower suction tube.

15. The machine of claim **14**, wherein said lower suction tube is at least partially movable axially and jointly with said removal element in order to maintain locking of the article at least along part of an upward motion of said removal element.

16. The machine of claim **15**, comprising removal actuation means for actuating said removal element with a controlled rotary motion about said vertical axis in order to position said removal element in a preset angular position around said vertical axis.

17. The machine of claim **16**, wherein said transfer element is selectively actuatable to move on command along a substantially horizontal transfer direction that forms a path from a position for gripping the article, in which the transfer element is arranged with said second grip means below a lower end of said removal element in a position in which the removal element is extracted upward from the upper needle cylinder, to a transfer position, in which the transfer element is moved laterally away from the upper needle cylinder, and vice versa.

18. The machine of claim **17**, further comprising a feeder guide for a sewing machine, located along at least one portion of the path of said transfer element and below said path, so as to allow insertion of a portion of the article in said feeder guide during passage of said transfer element from an article grip position to a transfer position.

19. The machine of claim **17**, wherein said second grip means of the transfer element comprise a supporting element that is movable on command along said transfer direction, and two grippers which are mounted on said supporting element.

20. The machine of claim **19**, wherein said two grippers are provided with jaws and are movable on command along a substantially vertical direction with respect to said supporting element in order to enter with one of said jaws of each one of said grippers through a lower end of said hollow outer cylinder.

21. The machine of claim **19**, wherein a first gripper of said two grippers is movable on command away from a second one of said grippers in order to widen the region of the article that is engaged by said grippers.

22. The machine of claim **19**, wherein each gripper of said two grippers comprises a first jaw and a second jaw that face each other, one of said jaws being movable on command toward or away from the other jaw in order to engage or disengage free portions of the article between two grip elements of a same pair of grip elements of said first grip means.

23. The machine of claim **22**, wherein said two grippers are rotatable on command about a substantially horizontal axis, said horizontal axis being parallel to said transfer direction, in order to overturn the article upon removal thereof from said removal element.

24. The machine of claim **19**, wherein said hollow outer cylinder has, starting from its lower end, two passages located in two mutually diametrically opposite regions thereof in order to allow engagement of said two grippers with the article.

25. A method for automated transfer of a tubular article, from a circular double-cylinder machine to a sewing machine, comprising the steps of:

sewing the article, while the last rows of stitches of the article are produced, at its axial or final end to be closed;

aspirating the article into the upper needle cylinder;

gripping the article proximate to its final end by means of a removal element that can be extracted upward from the upper needle cylinder;

disengaging the article from the needles of the machine that have manufactured it;

extracting the article upwardly from the upper needle cylinder by way of said removal element;

engaging the article at its final end by way of a transfer element;

disengaging the article from said removal element and inserting the article, by way of said transfer element, with a region proximate to its final end, in the feeder guide of the sewing machine.

26. The method of claim **25**, wherein said article is gripped, proximate to the final end thereof, by said removal element before ending said sewing step for manufacturing the article.

27. The method of claim **25**, comprising before completing extraction of the article from the upper needle cylinder, actuation of the machine to start manufacturing of a new article.

28. The method of claim **26**, comprising after said transfer element has gripped the article, flattening of said final end of the article by tensioning a region of the article that is engaged by said transfer element.

29. The method of claim **28**, comprising after engagement of said transfer element with the article and disengagement thereof from said removal element, turning over the article for arranging the final end thereof above a remaining part of the article.

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